THE AMERICAN MINERALOGIST
JOURNAL OF THE MINERALOGICAL SOCIETY OF AMERICA

Vol. 18 JANUARY, 1933 No. 1

CINNABAR AND ASSOCIATED MINERALS FROM PIKE COUNTY, ARKANSAS*

RUDOLPH G. SOHLBERG, *Stanford University.*

INTRODUCTION

During the early part of the summer of 1931, quicksilver ores were discovered in Pike County, southwestern Arkansas. While engaged in a petrographic examination of a suite of these ores for Dr. George C. Branner, State Geologist of Arkansas, I encountered several interesting mineral occurrences and relationships that appear to merit description. Prospecting is being carried on both in the central and eastern part of the county, near the towns of Crawford and Jackfork. A furnace is now in operation and economic appraisals of the deposits are being made.

The Mississippian and Pennsylvanian sandstones and shales, which cover the area, have been intensely folded and faulted. Miser and Purdue,[1] who have described the geology of the district, include an excellent map with their report.

RELATIONSHIP OF THE CINNABAR TO THE COUNTRY ROCK

The ore bodies are in the form of veins and disseminated masses in the lower part of the Jackfork quartzitic sandstone of Mississippian age. The veins follow, for the most part, the fractures and bedding planes of the sandstone, a gray to buff rock which has been firmly cemented with secondary quartz. The quartz grains measure, on the average, 0.1 mm. in diameter and have a well rounded appearance as if waterworn. Other detrital minerals present in the country rock include tourmaline, zircon, muscovite, chlorite, badly altered feldspar fragments, and occasional small grains of rutile. The feldspar has often been sericitized and rounded rock fragments are not uncommon. Most of the extensive fractures in the sandstone have been filled with vein quartz and it is in the interstices of these grains that the chief ore mineral, cinnabar, is

---

* Published by permission of the State Geologist of Arkansas.

[1] Miser, H. D., and Purdue, A. H., Geology of the DeQueen and Caddo Gap quadrangles, Arkansas: *U. S. G. S. Bull.* **808**, 1929.

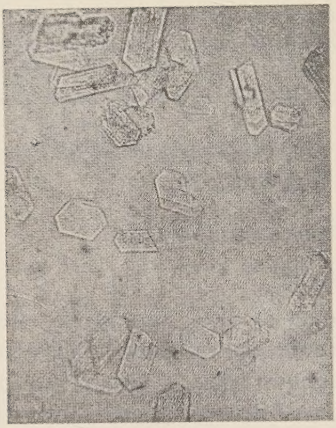


FIG. 1. (×ca. 130 diameters). Euhedral crystals of dickite mounted in Canada balsam. The crystals are slightly out of focus so as to bring the Becke line just within the crystal boundary, thus emphasizing the outline.

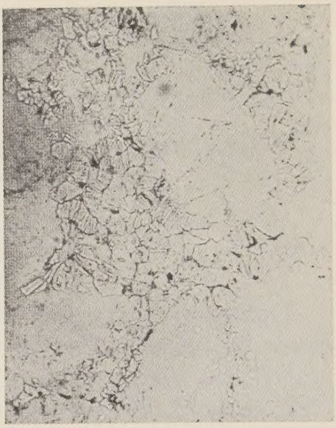


FIG. 2. (×ca. 100). Showing well developed dickite cyrstals in the vein quartz.

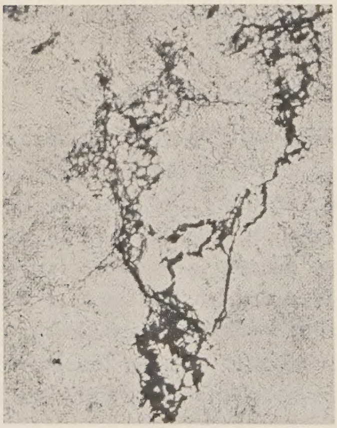


FIG. 3. (×ca. 100). The iron-bearing dickite has formed in the interstices of the vein quartz and is cut by irregular stringers of cinnabar (opaque). The normal dickite of lower double refraction replaces the quartz grains.

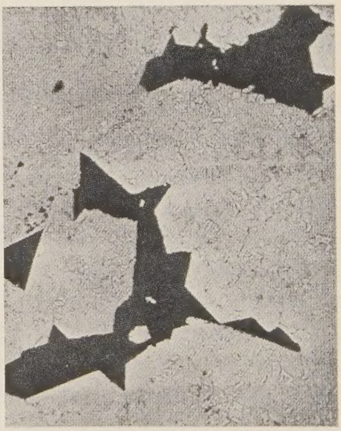


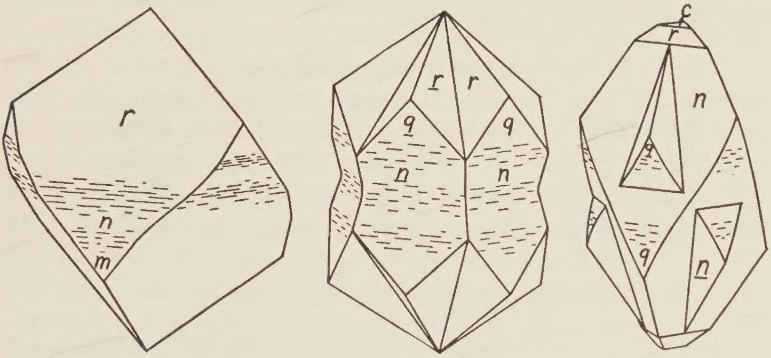
FIG. 4. (×ca. 100). The cinnabar (opaque) has formed around the quartz crystals which are replaced by the dickite.

found. The cinnabar has been deposited after the formation of the vein quartz for cinnabar often completely surrounds the quartz grains. In some instances very fine veinlets of cinnabar cut grains of vein quartz, but this is comparatively infrequent. In such cases the ore has probably filled small fractures caused by later movement. Although most of the ore is in the vein quartz, the country rock adjacent to the veins also carry stringers of cinnabar.

In some places the veins are separated from the country rock by narrow zones of gouge material. This crushed rock does not contain any cinnabar nor does the country rock close by; even when the ore is present in the vein bordering on the crushed zone.

EUHEDRAL CRYSTALS OF CINNABAR

Closer to the surface euhedral crystals of cinnabar occur in vuggy openings and along some of the bedding planes of the sandstone. These are generally twins although simpler untwinned individuals have been noted. The crystals vary in size from 1 to 7 mm. in length and are usually more or less malformed.



5 6 7

FIGS. 5, 6, 7. Clinographic projections of euhedral crystals of cinnabar. An attempt has been made to show the rounded and striated appearance typical of these crystals. Forms noted: $r\{10\bar{1}1\}$, $n\{20\bar{2}1\}$, $q\{40\bar{4}1\}$, $m\{10\bar{1}0\}$, and $c\{0001\}$.

The untwinned crystals are smaller and more perfectly formed than the twinned individuals. Although this observation may not be true for a larger number of specimens, it seems to be most often the case among those examined. As can be seen in Fig. 5, the simple

---

[2] According to Buckley and Vernon, the hexagonal prism and not the rhombohedron is the space lattice in cinnabar. Four indices rather than three should therefore be used. Buckley, H. E. and Vernon, W. S., *Miner. Mag.*, vol. **20**, p. 382, 1925.

crystals are rhombohedrons, the unit rhombohedron $r\{10\bar{1}1\}$ predominating with the steeper rhombohedron $n\{20\bar{2}1\}$, and the prism $m\{10\bar{1}0\}$ occurring as modifications.[2]

The twinned crystals, Figs. 6 and 7, are of the penetration type with the *c*-axis as the twin-axis. In addition to the forms present in the simpler crystals, another rhombohedron, $q\{40\bar{4}1\}$, the pinacoid $c\{0001\}$ and the trigonal trapezohedron $\kappa\{42\bar{6}3\}$ are present. Similar twinned crystals have been described by Tschermak[3] from Nikitovka, Russia, and by Termier[4] from Ouen-Shan-Tschiang, China. The penetration-twinning of crystals having the trapezohedron present is apparently very rare; for with the exception of the Nikitovka occurrence, which Tschermak describes as being twinned in the same manner, it is not known to have been found elsewhere. The unit rhombohedron almost always merges into the steeper rhombohedrons; the effect being a curved face. Some difficulty was encountered in accurately measuring the crystals as the faces, in addition to being curved, are often dull and striated. The differences between the values of the measured and recorded angles must be attributed to this cause.

TABLE OF INTERFACIAL ANGLES

		Measured	Recorded
cr	$(0001)\wedge(10\bar{1}1)$	53°34′	52°54′
rn	$(10\bar{1}1)\wedge(20\bar{2}1)$	17 30	16 24
cq	$(0001)\wedge(40\bar{4}1)$	78 00	79 18
$r\kappa$	$(10\bar{1}1)\wedge(42\bar{6}3)$	21 05	21 30
$r\underline{r}$	$(10\bar{1}1)\wedge(\underline{01\bar{1}\bar{1}})$	75 00	74 12

SECONDARY QUICKSILVER MINERALS

A number of interesting secondary quicksilver minerals are found closely associated with the cinnabar. Both calomel and native mercury in the form of globules fill many of the near surface cavities. Also, small amounts of a greenish-yellow mineral occur with the calomel as irregular masses. Fragments of this, mounted in Canada balsam, prove to be completely isotropic at room temperature. This mineral is eglestonite, previously described from Terlingua, Texas,[5] and San Mateo County, California.[6]

[3] Tschermak, G., *Min. u. Petr. Mitth.*, vol. **7**, p. 361, 1886.

[4] Termier, P., *Bull. Soc. Fran. Min.*, vol. **20**, p. 204, 1887.

[5] Moses, A. J., *Am. Journ. Sci.*, [4] vol. **16**, pp. 253–63, 1903.

[6] Rogers, A. F., *Am. Journ. Sci.*, [4] vol. **32**, pp. 48–50, 1911.

In places, the cinnabar has been thinly coated with metacinnabar,[7] the black, secondary sulfide of mercury. When the thin, opaque coating is heated with sodium carbonate in a closed tube, small globules of mercury result. The use of a polished surface provides no additional information as the polishing process employed destroys the coating. Allen and Crenshaw[8] state that metacinnabar is formed when descending dilute acid solutions come in contact with precipitating agents such as sulfides and organic matter. Broderick[9] has demonstrated experimentally that these waters must have a chloride composition, because sulfates, the only other salts likely to form, immediately hydrolyze to form an insoluble basic salt.

DICKITE AND OTHER ASSOCIATED MINERALS

Dickite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$), a mineral of the kaolin group and a polymorph of kaolinite and nacrite, is universally present in both the quartz veins and the fractures and bedding planes close to the surface. Singly terminated quartz crystals projecting from the walls of these fractures are very often covered with the dickite. In the hollows between the quartz crystals, places especially favorable for uninterrupted growth, the dickite is best developed, individual crystals measuring up to 0.15 mm. in length. The crystals are tabular in habit, occasionally twinned, and commonly form pseudohexagonal book-like aggregates. The optical character is biaxial positive with the optic plane normal to the crystal edge. The three principal indices of refraction, obtained by the immersion method, are $n_\alpha = 1.560$, $n_\beta = 1.565$, and $n_\gamma = 1.567$, all $\pm .002$. The maximum double refraction is thus .007 with a possible maximum error of $\pm .004$. The greatest extinction angle found was 15°.

The optical properties of dickite, while distinct from those of the non-kaolin minerals, are nearly similar to those of nacrite. As the dispersion and optical character may or may not be the same for these two minerals, the only certain difference optically is the maximum angle of extinction. Ross and Kerr,[10] who have made a special study of the minerals of the kaolin group, find that the

---

[7] Metacinnabar is preferred to metacinnabarite, used in Dana, and is believed to be the more consistent usage.

[8] Allen, E. T., and Crenshaw, J. C., *Am. Journ. Sci.*, [4] vol. **34**, p. 341, 1912.

[9] Broderick, T. M., *Econ. Geol.*, vol. **11**, p. 645, 1916.

[10] Ross, Clarence S., and Kerr, Paul F., The kaolin minerals: *U. S. G. S. Prof. Paper* **165E**, 1930.

x-ray diffraction patterns of the three minerals, kaolinite, dickite and nacrite are quite distinctive. An *x*-ray diffraction pattern of the kaolin mineral from this locality, furnished through the kindness of Dr. Kerr and interpreted by him, establishes beyond doubt the identity of this mineral as dickite. Although many of the dissimilarities in the *x*-ray diffraction patterns become apparent only upon close measurement, a few can be detected by inspection. See Fig. 8.

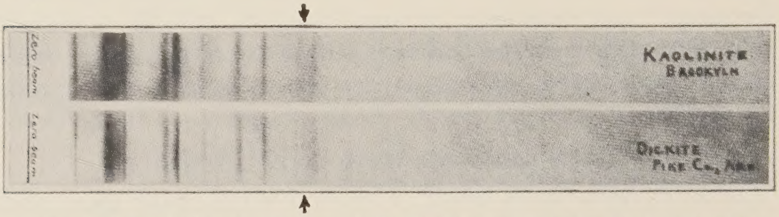


FIG. 8. *X*-ray diffraction pattern of the dickite associated with the quicksilver ores in Pike Co., Ark., with a comparison pattern of kaolinite from Brooklyn, N. Y. Some of the more apparent differences in the arrangement of the lines are marked by arrows. (*Photographed by Paul F. Kerr.*)

In the vein quartz, the dickite is observed replacing the quartz grains themselves as well as being present in the interstices. Often this interstitial dickite assumes a brown-yellow color and possesses a somewhat higher double refraction than the normal variety, leading to the suspicion that iron may be present in solid solution. A quantitative determination of iron by chemical means would be of little value as some iron stain is also present.

The indices of refraction of the brown-yellow variety are $n_\alpha = 1.560$, and $n_\gamma = 1.572$, $\pm .002$, giving a maximum birefringence of .012, $\pm .004$. The birefringence was also determined by means of a Berek compensator, eliminating a possible total error of .004 which may result from the use of index liquids. The compensator values were .004 for the normal dickite and .006 for the brown-yellow variety. The discrepancy between the compensator values and the values obtained through the use of index liquids can only be explained by assuming that some of the dickite, which is soft, has been removed during the grinding of the section, rendering it thinner than the more resistant quartz which was used to determine the thickness of the section.

The brown-yellow dickite occurs as irregular stringers between the grains of the vein quartz, indicating that the iron-bearing solutions affected only the dickite along the more permeable parts of the vein and not that replacing the quartz. Most of the cinnabar has undoubtedly been deposited soon after the dickite was formed because veinlets of cinnabar cut patches of dickite. Occasionally, however, cinnabar veinlets continue as veinlets of dickite, the transition from one to the other being almost imperceptible. As dickite is regarded of hydrothermal origin,[11] the close association of dickite with cinnabar, typical of all specimens examined, strongly indicates a hydrothermal origin for these deposits.

Goethite is present as a colloform coating on a number of the quartz crystals near the surface. Hyalite opal has formed both on the quartz and the goethite, partly as colloform crusts and partly as thread-like masses resembling spider-webs. A small amount of stibnite associated with stibiconite has been noted in one instance. The stibiconite is an alteration product of the stibnite and the bladed appearance of the latter is preserved in the stibiconite. Small particles of cinnabar are present in the stibiconite and as there are all gradations between these particles and the massive cinnabar, the cinnabar must be later than the stibnite.

The dickite is often gashed as if a mineral had been removed by solution. Though these gashes appear somewhat regular in outline, a possible determination of their former content by angular measurement of the gashes proved unsuccessful.

Summary

After the folding and faulting of the region, hydrothermal solutions rose along the fractures and fissures of the Jackfork quartzitic sandstone, depositing vein quartz, dickite and cinnabar in the order named but with some local overlapping. The dickite replaces the vein quartz and is in turn cut by thin veinlets of cinnabar. The solutions and vapors which formed the cinnabar were probably of an alkaline nature. Later, descending acid solutions altered the cinnabar, producing the secondary quicksilver minerals, metacinnabar, calomel, and eglestonite. The same solutions are, in all probability, also responsible for the high iron content in some of the dickite. Opal was the last mineral to form.

Acknowledgments

The writer is indebted to Dr. Austin F. Rogers, under whose guidance this work was done, and whose many helpful suggestions

---

[11] Ross and Kerr, *Op. cit.*

and criticisms have been greatly appreciated; to Dr. Paul F. Kerr for photographing and interpreting the *x*-ray diffraction pattern; and to Dr. George C. Branner for permission to publish this article.

CRYSTALLOGRAPHIC DATA ON MELLITE

Tom. F. W. Barth and C. J. Ksanda, *Geophysical Laboratory.*

I

Mellite is one of the few organic minerals. Its formula is $Al_2C_{12}O_{12} \cdot 18H_2O$, which corresponds to a hydrous salt of the hexacarboxylic mellitic acid, and is thus far the only representative of the benzene ring in the mineral kingdom. It occurs in coal seams in middle Europe and Russia; the tetragonal crystal form is frequently nicely displayed by very simple face combinations. In Goldschmidt's "Atlas der Kristallformen" only the following forms are listed: (001), (010), (110), (011), and (111). The crystals are semi-transparent with a honey-yellow color, from which the mineral takes its German name, Honigstein. As far as the authors are aware no recent investigation of this mineral is on record. Des Cloizeaux in his "Manuel de Minéralogie" (vol. **2**, p. 70) gives a good description of it, but in more recent textbooks very little space is devoted to it.

Through the courtesy of Professor F. Bernauer, Technische Hochschule, Berlin-Charlottenburg, several beautiful, small crystals from Artern in Thuringia were sent to us for *x*-ray investigation.

II

Rotation photographs with the crystal rotating about the *a*-axis and the *c*-axis were obtained by using Fe-K_α-radiation. From these photographs it was found that the primitive translations along these directions were:

$$a_0 = 22.0\,\text{Å}$$
$$c_0 = 23.3\,\text{Å}$$
$$a_0/c_0 = 1.055$$

Since the crystallographic axial ratio a'/c' is given as 0.7463, this means that the crystallographic *a*-axis should be rotated 45° in order to correspond with the internal symmetry of the crystal, the crystallographic axial ratio being obtained by dividing the true axial ratio by $\sqrt{2}$.

In the unit cell, which is nearly a cube, there must be 16 molecules of the formula $Al_6C_{12}O_{12} \cdot 18H_2O$; the calculated density of the crystal then becomes, $D=1.65$. Direct determinations on three crystals from Artern gave: 1.574, 1.636, 1.642 (according to Kenngott).

To check the size of the unit cell a Laue photograph was taken with the beam of incidence slightly inclined to the direction of the *c*-axis (tungsten target, 60 k.v. tension). The Laue diagram produced in this way is reproduced in Fig. 1. It contains more than 500 spots all of which have been indexed. It should not be necessary, however, to tabulate all of them here, for a few critical spots suffice to prove the correctness of the proposed unit cell. It is seen that the spots closest to the primary beam on the left-hand side of the photograph are much weaker than the corresponding spots on the right-hand side. Since the structure factor is the same for any two planes belonging to the same form, the weakening on the left-hand side is due solely to the fact that these planes reflect *x*-rays, the wave lengths of which lie close to the low wave-length limit.

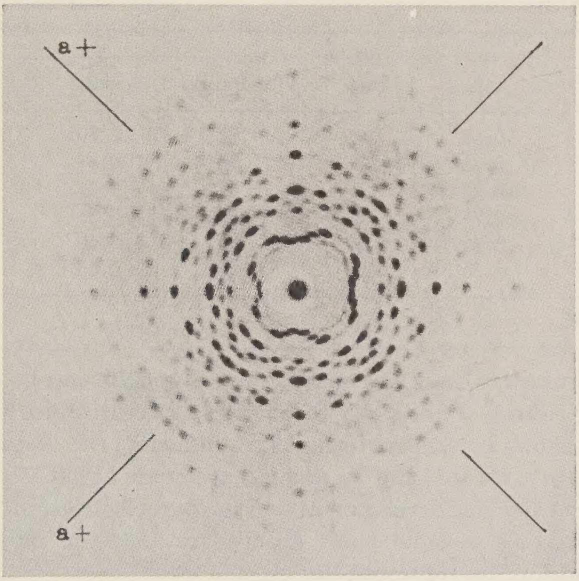


Fig. 1. Laue Photograph of Mellite.

Table 1 gives the indices of these 12 planes with calculated wave lenths and observed intensities of the reflected *x*-ray beams. It is evident that the minimum wave length must be about $\lambda_{\min} = 0.25\text{Å}$, which corresponds to the tension applied, 60 k.v., thus corroborating the correctness of the proposed cell.

TABLE 1.

CRITICAL SPOTS ON THE LAUE DIAGRAM PROVING THE CORRECTNESS OF THE PROPOSED UNIT CELL.
(60 k.v. W—target)

Left-hand side			Right-hand side		
Indices	λ calc.	Int. obs.	Indices	λ calc.	Int. obs.
931	0.39	10	$\overline{9}\overline{3}1$	0.50	10
951	0.32	2	$\overline{9}\overline{5}1$	0.43	6
971	0.26	3	$\overline{9}\overline{7}1$	0.35	10
791	0.25	3	$\overline{7}\overline{9}1$	0.35	10
591	0.28	2	$\overline{5}\overline{9}1$	0.40	6
391	0.36	10	$\overline{3}\overline{9}1$	0.46	10

III

The symmetry class and space group of mellite can be deduced from the nature of the *x*-ray diffraction patterns. Since the Laue diagram shows holohedral tetragonal symmetry, the classes C_4, S_4, and C_{4h} are excluded; and V_d and C_{4v} are made highly improbable by the external face development and the pyroelectrical properties.[1] The remaining possible point groups are D_{4h}, the bipyramidal class, and D_4, the trapezohedral class.

There are 30 different space groups in these classes and a discrimination between them can only be made by the application of space-group criteria, *i.e.*, special extinctions in the *x*-ray diffraction pattern. An analysis of the Laue photograph shows that all types of planes occur in all orders. The fundamental lattice is therefore the simple tetragonal lattice, Γ_t, the correct space group is either D_{4h}^1, D_{4h}^7, or any one of the first 8 in D_4, but a further distinction cannot be made from the Laue diagram, because the presence or absence of odd order reflections from (100) and (001) are critical. An *x*-ray goniometer photograph (Weissenberg picture) was therefore obtained with the crystal oscillating about the *c*-axis, Mo-K_α-radiation. A complete record of this film will not be given: the data of interest in this connection are compiled in Table 2, from which it is seen that 100 is present in the 3d and 5th orders, consequently D_{4h}^1—P4/m m m—is the only possible space group in the bipyramidal class.

---

[1] Cf. W. G. Hankel, *Abh. kgl. sächs. Ges. Wiss.*, (math.-phys. Kl.), **12**, 552, 1882.

TABLE 2.

OBSERVED *X*-RAY REFLECTIONS FROM THE SECOND ORDER TETRAGONAL PRISM.
(Mo-K_α-radiation)

Intensities	Spacing	Indices	Order	a_0
1	7.3	100	3	21.9
10	5.4	100	4	21.6
4	4.36	100	5	21.8
2	2.71	100	8	21.7
4	1.83	100	12	22.0
1−	1.57	100	14	22.0
2	1.36	100	16	21.8
1−	1.22	100	18	22.0
4	1.095	100	20	21.9

Oscillation photographs on the base show very definitely that most orders of 001 are extinguished: only the 4th and 8th orders have been observed.

This observation was carefully checked by the use of soft radiation ($\lambda = 2.286$Å, Cr-K_α) and long exposure. But no trace could be seen of any basal reflections other than the 4th and the 8th orders (see Table 3). The missing reflections—all orders of 001 not divisible by 4—constitute thus the only systematic extinctions encountered in the diffraction spectrum of mellite.

TABLE 3.

X-RAY REFLECTIONS FROM THE BASE.
(Cr-K_α-radiation)

Intensity	Spacing	Indices	Order	c_0
10	5.80	001	4	23.2
10	2.93	001	8	23.4

It is generally true that it is safe to use the presence but not the absence of reflections for distinguishing between space groups. But in view of the fact that mellite has such a large unit cell with a great many atoms in the generally equivalent positions, the systematic extinctions become very significant, and it should be permissible to use the absence of certain reflections as space-group criteria.

If the absent reflections are *not* accepted as criteria, the space group D_{4h}^1 and its sub-group D_4^1 still remain as possibilities, but in all probability the space groups D_4^3 and/or D_4^7, which are the only ones requiring the characteristic extinctions encountered in mellite,[2] are the correct ones. This means that mellite must be placed in the trapezohedral class of the tetragonal system, which is interesting because thus far no other mineral has been encountered with such symmetry. The two space groups, D_4^3–$P4_12$, and D_4^7–$P4_32$, are enantiomorphic: the one is the mirror image of the other, and a distinction between them cannot be made by means of *x*-rays. Some crystals of mellite may be left-handed and belong to D_4^7 while others may be right-handed and belong to D_4^3. Examples of compounds exhibiting enantiomorphic symmetry, some crystals of which are left-handed while others are right-handed, are recorded in the literature.

Crystals isomorphous with the groups D_4^3 and D_4^7 should rotate the plane of polarization of light, and also exhibit characteristic etch-figures. Thus a conclusive proof of the space-group determination would be afforded if any such properties of mellite could be demonstrated. However, this is not the case: on a plate of mellite, 1 mm. thick cut normal to the *c*-axis, the typical anomalously biaxial interference figure, $(-)2V=8°$, was observed, but no indication of circular polarization could be detected. The etch-figures on the base (produced by means of very dilute HNO_3) are squares, the outlines of which are parallel to the traces of the second order tetragonal prism. It is thus evident that no other crystallographic properties, except the *x*-ray diffraction effects, indicate that mellite crystallizes with trapezohedral rather than bipyramidal symmetry.

A more detailed knowledge of the actual atomic arrangement in mellite cannot be obtained. There are 16 equivalent points in the general positions of D_{4h}^1, and since there are also 16 molecules in the unit cell, it becomes highly probable that all molecules ($Al_2C_{12}O_{12} \cdot 18H_2O$) are structurally identical, and repeated 16 times within each unit according to the crystallographic symmetry of this space group, therefore the molecule itself need not have any symmetry properties, the location of each individual atom in the molecule being determined by an independent set of three parameter values, *xyz*; since there are 80 atoms within each molecule no less than $80 \times 3 = 240$ different parameter values determine the complete structure of mellite. The full formula for the unit cell is: ($Al_{32}C_{192}O_{480}H_{576}$).

---

[2] See, for instance, K. Herrmann, Auslöschungstabellen, *Z. Krist.*, **68**, 288, 1928.

An arrangement in D_4^3 or D_4^7 differs from the one in D_{4h}^1 in that it has twice as many degrees of freedom: 460 parameter values. It is therefore obviously impossible, from the diffraction effects alone, to give even the slightest suggestion as to the actual atomic arrangement within the unit of structure, and since we know so little about the configuration and general leptologic relations of the H_2O-group in hydrous compounds, it is, for the time being, impossible to solve completely the structure of mellite.

SUMMARY

From *x*-ray data obtained from rotation, oscillation, *x*-ray goniometer, and Laue photographs the unit of structure of mellite was found to be a tetragonal prism, the dimensions of which are: $a_0 = 22.0$Å, $c_0 = 23.3$Å, $a_0/c_0 = 1.055$, comprising 16 molecules of the formula ($Al_2C_{12}O_{12} \cdot 18H_2O$); calculated density 1.65. Although the geometrical and the physical properties of mellite correspond to a holohedral crystal symmetry, very definite space-group criteria indicate that the mineral is really isomorphous with D_4^3 and/or D_4^7, two enantiomorphic groups in the trapezohedral class; mellite thus being the first known mineral exhibiting tetragonal trapezohedral symmetry. The atomic arrangement depends on at least 240 parameters.

USE OF THE CAMERA LUCIDA IN CRYSTAL DRAWING*

WALLACE M. AND JOSEPHINE W. MCNABB
Chemistry Department, University of Pennsylvania,
Philadelphia, Pa.

INTRODUCTION

In publications referring to the use of the gnomonic projection of V. Goldschmidt (1) for the drawing of crystals, no mention has been made of the application of the camera lucida in conjunction with this method. In the construction of a drawing of an ideal crystal the dimensions may be made to correspond to the symmetry of the class to which the particular crystal belongs. However, if a drawing is desired which will reproduce the actual distortion of a typical crystal, the personal judgment of the individual worker must be relied upon to portray the exact condition, and therefore the accuracy of the drawing may vary in each case. The camera lucida attached to a stereoscopic microscope focused on the crystal in a certain position, as herein described, permits a tracing to be made of the edges between the various faces on the crystal, and with this sketch used as the basis for the orthogonal drawing as it is made from the gnomonic projection, errors due to judgment of the individual are entirely eliminated.

DIRECTIONS FOR USE OF THE CAMERA LUCIDA

In the orthogonal projection, as it is constructed from the gnomonic projection, all edges appear parallel that are parallel on the crystal when the position of the eye is considered to be at infinity and vertically above the crystal. These conditions are also fulfilled in a camera lucida drawing when the crystal is brought in the following position. The crystal to be drawn is mounted on white paper and held so that the lower end is embedded in a small amount of wax. It is placed on the stage of a binocular microscope and the crystal is moved into a position so that its vertical axis coincides in direction with the focal field of the right tube of the microscope, the camera lucida being attached to this tube. This position may be determined by observing the crystal, none of the prism sides should be visible if they are all parallel to the axis of the focal field, and only the top faces of the crystal, as they will appear later in the orthogonal drawing, will be seen. The camera lucida must be adjusted so that the angle through which the image is reflected to the drawing board is 90°. (The tubes of the stereoscopic microscope are slightly inclined, but this inclination is not sufficient to distort the image, within the limits of magnification conveniently used, as may be demonstrated by actual measurement of camera lucida tracings of divisions of a stage micrometer placed in different positions on the microscope stage.)

---

* The authors wish to thank Dr. Edgar T. Wherry for criticism of this article.

The top and bottom portions of the crystal are sketched separately. It is necessary to remount the crystal to sketch the bottom. Of the two drawings, one is reversed, the other is superimposed in the proper position, and they are held up against a window pane where the bottom faces may be drawn in with dotted lines, thus producing a perspective drawing. The last drawing is then placed in the correct position beside the gnomonic projection, the position being determined by the direction of the edges between corresponding faces and poles. The direction of the edge between two faces in an orthogonal projection is at right angles to the zone line containing the poles of the faces in a gnomonic projection. Each edge of the camera lucida drawing of the crystal is checked and any slight errors made in drawing the lines are corrected; the direction as indicated by the gnomonic projection being considered more accurate. If a small face on the crystal has been inadvertently omitted in making the camera lucida sketch, the drawing will fail to check with the gnomonic projection. Thus the final drawings must contain all faces as they appear on the actual crystal. It is necessary to make a camera lucida drawing only of the top and bottom of the crystal, as the proportions in the parallel perspective drawing follow from the orthogonal plan. However, the length of one prism edge must be marked off, using the camera lucida, if the correct length of the crystal is desired in the parallel perspective drawing. Details of the standard procedure used in making drawings from the gnomonic projection are given by Porter (2).

The size of the crystals to which this combination method may be applied is dependent upon the degree of magnification necessary to give a drawing of proper dimensions. Drawings should be large enough to avoid crowding of the orthogonal plan and thus prevent inaccuracy in the construction of the parallel perspective drawing. Magnifications up to 160 diameters are found to give accurate camera lucida drawings. Above this magnification there is a certain amount of distortion. The method may be applied to crystals from about 0.1 mm. to 1 mm. diameter, a range which includes most artificial crystals.

Crystal Drawings Demonstrating the Use of the Camera Lucida in Conjunction with the Gnomonic Projection

A gonomonic projection was constructed from average values obtained from the measurement on a two-circle goniometer of 15 crystals of potassium sulphate (Table 1). This was used to check a camera lucida drawing of a typical crystal, in constructing the drawings shown in figure 1. In figure 1 the crystal is magnified 107 diameters, the greatest diameter being 0.45 mm. This demonstrates the use of the method as applied to a crystal with a considerable number of faces.

Table 1.

Potassium Sulphate

Averages obtained from measurement of 15 crystals.

No.	Form	Symbol	Angles measured		Angles calculated	
			ϕ	ρ	ϕ	ρ
1, 2	*b*	011	0°05′	29°49′	0°00′	29°49′
3, 4, 5, 6	*c*	111	53°24′	43°50′	53°42′	44°04′
7, 8, 9, 10	*d*	211	69°36′	58°44′	70°15′	58°54′
11, 12	*e*	031	0°01′	59°48′	0°00′	59°49′
13	*a*	001	—	0°00′	—	0°00′
14, 21, 26	*f*	120	33°25′	90°00′	43°15′	90°00′
15	*g*	11–20–0	36°13′	"	37°32′	"
16, 18, 23, 25	*h*	110	53°57′	"	53°42′	"
17, 24	*i*	100	89°59′	"	90°00′	"
19	*j*	580	40°23′	"	40°24′	"
20, 28	*k*	010	0°03′	"	0°00′	"
22	*l*	340	45°34′	"	45°37′	"
27	*m*	140	19°52′	"	18°48′	"
29	*n*	380	28°41′	"	27°03′	"

$p_0 = 0.7802$; $q_0 = 0.5731$; $a:b:c = 0.7346:1:0.5731$.
Groth (6) gives 0.7418:1:0.5727.

Artificial crystals of oxalato-tetrammine-cobalti-chloride, prepared by Dr. H. A. Altsentzer, using the method of Jörgensen (3), were recrystallized from water in order to obtain crystals suitable for measurement. The crystals are ruby red in color, belong to the rhombic bipyramidal class and apparently are isomorphous with the oxalato-tetrammine-cobalti-nitrate as described by Jaeger (4). In development they approach very closely the tetragonal system.

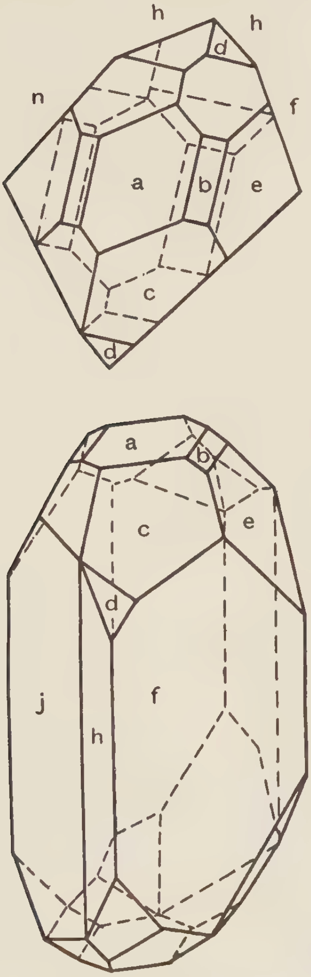


FIG. 1. Potassium sulphate.

TABLE 2.

OXALATO-TETRAMMINE-COBALTI-CHLORIDE

Averages obtained from measurement of 12 crystals.

No.	Form	Symbol	Angles measured		Angles calculated	
			ϕ	ρ	ϕ	ρ
1, 2	*a*	011	0°13′	32°44′	0°00′	32°41′
3, 4	*c*	101	89°59′	44°52′	90°00′	44°53′
5, 8	*d*	010	0°03′	90°01′	0°00′	90°00′
6, 7, 9, 10	*e*	110	57°06′	90°01′	57°09′	90°00′

$p_0 = 0.9963; q_0 = 0.6428; a:b:c = 0.6458:1:0.6428.$

Average results of measurements obtained from 12 crystals are given in table 2. A gnomonic projection of these results was made on a printed chart (Porter, Oxford Univ. Press) and used in conjunction with the camera lucida drawing. Figure 2 gives an accurate reproduction of a typical crystal. The upper sketch consists of the camera lucida drawings of the top and bottom which are superimposed and then checked with the gnomonic projection. The lower drawing of figure 2 is a parallel perspective made from the above orthogonal plan with the aid of the gnomonic projection. The crystal is magnified 107 diameters in the drawing, the actual size of the crystal being 0.34 mm. at the greatest diameter.

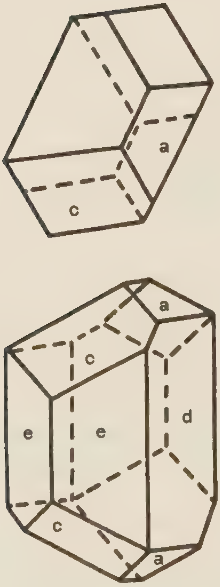


Fig. 2. Oxalato-tetrammine-cobalti-chloride.

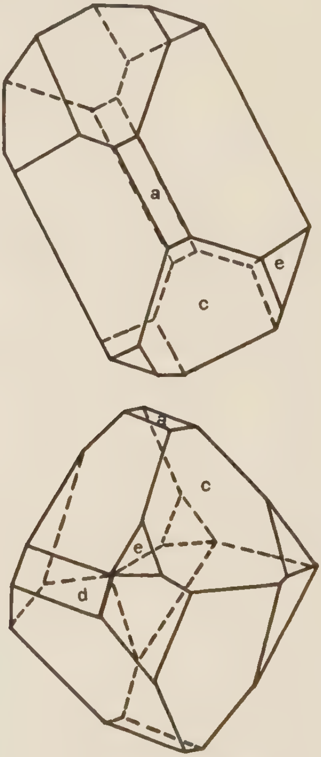


Fig. 3. Hexammine-cobalti-perchlorate.

Hexamine-cobalti-perchlorate was prepared by the method used by Wyckoff, Hendricks and McCutcheon (5) who determined its x-ray pattern. Average results of the measurement of 12 crystals are given in table 3. The crystals are isometric, amber colored, and show combinations of the cube, octahedron and dodecahedron.

TABLE 3.

HEXAMMINE-COBALTI-PERCHLORATE

Averages obtained from measurement of 12 crystals.

No.	Form	Symbol	Angles measured		Angles calculated	
			ϕ	ρ	ϕ	ρ
1	*a*	001	—	0°00′	—	0°00′
2, 3, 4, 5	*b*	112	45°05′	35°19′	45°00′	35°16′
6, 7, 8, 9	*c*	111	45°00′	54°42′	45°00′	54°44′
10, 12	*e*	021	0°02′	63°26′	0°00′	63°26′
11, 13	*e*	201	89°59′	63°26′	90°00′	63°26′
14, 15, 16, 17	*d*	110	44°59′	90°03′	45°00′	90°00′

$a:b:c=1:1:1$

Figure 3 is a drawing of a typical crystal using the camera lucida and gnomonic projection. The crystal is magnified 54 diameters, the actual size of the crystal being 0.93 mm. at the greatest diameter.

SUMMARY

A method for drawing typical crystals accurately is described. The method combines the use of the camera lucida and the gnomonic projection; a camera lucida drawing being used as the basis of the orthogonal plan.

The method is especially applicable to artificial crystals, the size conveniently used being about 0.1 mm. to 1 mm. in diameter.

Oxalato-tetrammine-cobalti-chloride crystals are ruby red and belong to the rhombic bipyramidal class. The axial ratio is: $a:b:c=0.6458:1:0.6428$.

Hexammine-cobalti-perchlorate crystals are amber colored and isometric. Combinations observed were: cube, octahedron and dodecahedron.

REFERENCES

(1) V. Goldschmidt, *Zeit. Kryst.*, **19**, p. 352, 1891.

(2) Mary W. Porter, *Amer. Min.*, **5**, p. 89, 1920.

(3) Jörgensen, *Zeit. Anorg. Chem.*, **11**, p. 420, 1896.

(4) F. M. Jaeger, *Zeit. Kryst.*, **39**, p. 563, 1903–04.

(5) R. W. G. Wyckoff, S. B. Hendricks and T. P. McCutcheon, *Amer. Jour. Sci.*, **13**, p. 388, 1927.

(6) P. Groth, Chemische Krystallographie, Part 2, p. 337, *Leipzig*, **1908.**

OXIDATION PRODUCTS OF PITCHBLENDE FROM BEAR LAKE

Charles Palache and Harry Berman, *Harvard University*.

The uranium-silver ores of Great Bear Lake have been described by Spence and Kidd[1] who devoted their chief attention to the place and mode of occurrence of the veins and to the primary ore minerals. The large collection of material collected by Spence in 1931 contained a number of specimens in which the ore was brilliantly colored by a variety of oxidation coatings. The best of these were selected and sent to the Harvard Mineralogical Laboratory for possible identification. It proved on examination of the specimens that the coating films and tiny veins containing the oxidation products were so thin that very little material of any one kind could be obtained. However, some results were obtained which are presented here as a preliminary report. More and better material for description may be obtained during the mining season of 1932 in which case it is hoped that a more conclusive examination may be made.

The specimens are for the most part fragments of the botryoidal pitchblende said to come from vein No. 2 (?). Quartz and barite are present in most of them and they are traversed by a network of thin veinlets which when broken open show crystalline coatings. Surfaces are also veneered with mamillary coatings of bright orange, yellow, red and green color but these substances proved generally to be colloids which could not be definitely determined. The minerals containing uranium which were found were:—

(a) Mineral X, an oxide of uranium closely related to becquerelite but possibly a new species.
(b) Uranophane.
(c) Zippeite.
(d) A crystalline mineral Y.
(e) Colloidal substances.

(a) Mineral X

This mineral occurs on most of the specimens but never in large amount. The largest crystal was under a millimeter in diameter and generally the crystals were too small to be readily seen as individuals even with a lens. The crystals are thin plates which often stand edgewise in drusy coatings on the walls of small vugs in the veinlets. Barite and quartz accompany mineral X, and the other oxidation products of the uraninite when present seem to be later. The crystals of mineral X are shining plates with a perfect cleavage, taken as basal pinacoid. The plates are in subparallel groups but in some of the smallest crystals which could be handled the deviation from parallelism was slight so that fairly reliable crystal measurements could be made. The color is lemon yellow to yellowish brown. Hardness about 3. Cleavage basal, very perfect. The optical properties are given in tabular form below together with those of becquerelite and schoepite.

---

[1] Spence, Hugh S., Radium and Silver at Great Bear Lake: *Mining and Metallurgy*, March, **1932.** Kidd, D. R., A Pitchblende Silver Deposit, Great Bear Lake, Canada: *Econ. Geol.* **27,** 145, 1932.

TABLE OF OPTICAL PROPERTIES

	Mineral X*	Becquerelite*	Schoepite
Color	Yellow	Brown to yellow	Yellow
H	3+	2–3	
Opt. Char.	(−), 2V med. large	(−), 2V = 30° ±	(−), 2V = 90° ±
Disp.	$\rho > v$, strong	$\rho > v$	$\rho > v$
Pleoch.	X = colorless Y & Z = yellow	X = colorless Y & Z = yellow	X = colorless Y & Z = yellow
α	1.785	1.735	1.690
β	1.810	1.820	1.714
γ	1.820	1.830	1.735
Orient.	X = c, Y = b	X = c, Y = b	X = c, Y = b
Cleavage	(001), perfect	(001), perfect	(001), perfect

* Optics by H. Berman

CRYSTAL FORM. Mineral X is orthorhombic and pseudotetragonal. The habit is tabular parallel to the base with elongation of the tablet in the direction of the b axis. Eight crystals were measured but only three gave readings at all consistent, and the only form used for calculating the axial ratio was a pyramid which is taken as the unit pyramid.

	ϕ	ρ
(111)	63°54′	67°07′

$p_0 = 2.12\,(8)$ $a = 0.49\,(0)$

$q_0 = 1.04\,(2)$ $c = 1.04\,(2)$

Forms:—(001), (010), (100), (120), (111), (011), (021).

	Calculated		Observed				No. of Obs.
	ϕ	ρ	ϕ		ρ		
120	45°35′	90°00′	44°49′	45°19′	90°		3
011	0	46°11′			45°21′	45°22′	2
021	0	64°22′			65°11′	65°45′	2
111	63°54′	67°07′	63°05′	64°18′	66°51′	67°32′	6

The form relations of mineral X, schoepite and becquerelite are shown in tabular form below. The choice of elements is based on schoepite, for which Mr. Berman determined the unit cell by means of rotation *x*-ray photographs. His result agreed with that of Walker,[2] not that of Ungemach,[3] who doubled the *a* axis of Walker to simplify symbols.

For becquerelite we have doubled the *c* axis as given by Schoep and Ungemach.

TABLE OF CRYSTAL ELEMENTS

	a	*c*	p_0	q_0
Schoepite	.4262	.875	2.054	.875
Mineral X	.490	1.04 (2)	2.12 (8)	1.04 (2)
Becquerelite	.5591	1.210	2.164	1.210

It will be observed that the mineral X is exactly intermediate in form between the other two closely related minerals.

CHEMICAL COMPOSITION. It was impossible to obtain satisfactory material for an analysis. A small sample of .12 grams not wholly pure was analyzed by Mr. Gonyer as shown below in Column 1. These figures are compared with the analyses of schoepite and becquerelite. It is evident that none of these analyses are satisfactory. They were probably made on small amounts of insufficiently purified material. The lead, always present, has been ignored in the accepted formula. In the case of mineral X there is somewhat more lead but in another sample, smaller but very pure, which was analyzed qualitatively, lead was absent. If so the lead in the analysis is to be ignored and mineral X receives the same formula as schoepite and becquerelite.

---

[2] *American Mineralogist*, **8**, 67, 1923.

[3] *Ann. Soc. geol. Belg., Congo Belge*, **52**, Fasc II, c79, 1929.

TABLE OF CHEMICAL ANALYSES

	1	2	3	4	5	6	7
H_2O	8.29	8.73	5.82	10.02	11.24	11.27	11.18
UO_3	76.10 (U_3O_8)	81.63	86.51	82.73	84.99	79.01	88.82
PbO	9.16	9.64	5.25	5.38	.97	4.56	
insol	4.10				3.71	2.76	
Fe_2O_3			0.54		.49	1.32	
SiO_2			0.83				
SO_3			1.01				
TeO_3						1.09	
	97.65	100.00	99.96	98.13	101.40	100.01	100.00

1. Mineral X analyzed by Gonyer.
2. Mineral X recalculated to 100%, omitting insoluble and converting U_3O_8 to UO_3.
3. Becquerelite: A. Schoep, analyst. *Bull. de la Soc. Min. Fr.*, vol. **47**, 1924, pp. 147–157.
4. Becquerelite "
5. Schoepite "
6. Schoepite "
7. Calculated for $UO_3 \cdot 2H_2O$.

(b) URANOPHANE

This mineral occurs as a green to yellowish green crust, made up of minute needles, too small for accurate microscopic work. The indices and orientation, however, suggest a mineral closely related to uranophane. Qualitative chemical tests show an abundance of silica and the other elements of uranophane, as well as some copper, the green color being probably in part due to this latter constitutent. From the specimens at hand it seems improbable that a satisfactory sample for analysis can be obtained, since the crusts are very thin and intimately mixed with other uranium compounds.

(c) ZIPPEITE

This material was found on only one specimen in clearly defined tufts, which yielded a good check optically, with zippeite. Another specimen showed the same material as a very thin crust. Apparently the zippeite has been formed after mineral X since it is found on that material. Only enough material for an optical examination was available.

(d) MINERAL Y

Mineral Y is a red uranium compound which forms tiny crystalline tufts. The crystals are not large enough for measurement on the goniometer; the refractive indices are higher than 2.06. Apparently this substance is a lead uranium compound, or an anhydrous uranium alteration product. No definite information has been obtained mainly because of the scarcity of the material. It is probably near curite.

(e) Colloidal Substances

A number of colloidal, or very finely crystalline uranium compounds have been found in the veins in which the above described minerals occur. The yellowish isotropic material seems to grade into the finely crystalline mineral X, and no doubt has a similar composition. Some of the waxy crusts are green or brown, or red. These are probably hydrous uranium compounds, with copper, perhaps, in the case of the green material.

GARNETS FROM SIERRA TLAYACAC, MORELOS, MEXICO

Duncan McConnell, *Cornell University.*

There are several varieties of garnet found in the Sierra Tlayacac. A pink variety (rosolite[1]) from this locality has been described as to chemical composition and specific gravity, but apparently no determination of the refractive index has been recorded, nor is there any description of the several other varieties which occur in the same formation.

The Cornell collection contains abundant material from this locality collected by the late Professor A. C. Gill, during his visit to Mexico in 1893–4. The garnets occur in euhedral forms in a contact rock which is distinctly a "Kalk-silicat-hornfels" produced by a reaction between a sandy limestone conglomerate or breccia (probably of Tertiary or late Mesozoic age) and massive Tertiary dikes. The garnets undoubtedly represent hydrothermal alteration products of the impure limestone. The associated minerals are chiefly wollastonite, vesuvianite, and calcite.

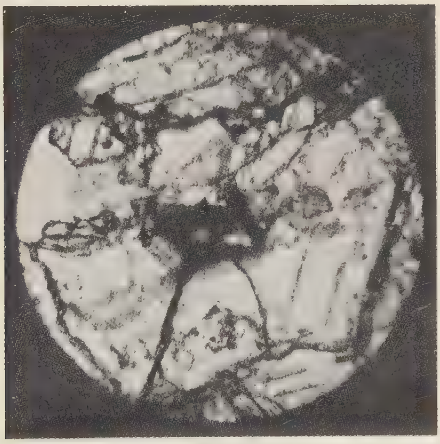


Fig. 1. Greenish-yellow garnet showing zonal structure and dark core (41×).

Where the garnetiferous material has weathered, the garnets stand out in relief and frequently constitute the only remaining component of a porous mass which has been called "garnet sponge."

---

[1] Also landerite and xalostocite, see L. J. Spencer: *Miner. Mag.*, **14**, 402, 1907.

Successive changes in composition of the hydrothermal solutions are quite apparent through zonal growth of the crystals (Fig. 1). This is to be observed in the rosolite as well as in the pale greenish-yellow garnet illustrated.

The predominant form of the garnets is the rhombic dodecahedron though some dark massive garnet occurs. Many of the pale greenish-yellow crystals and some of the pink ones contain a dark core.

CHEMICAL COMPOSITION

Two analyses of the pink material are recorded, those of M. A. Damour[2] and C. F. de Landero:[3]

	Damour	de Landero
Density	3.57	3.516*
SiO_2	39.46	40.64
Al_2O_3	21.69	21.48
Fe_2O_3	1.36	1.57
CaO	35.75	35.38
MgO	0.67	0.75
MnO_2	0.96	trace
Unattacked mineral	—	0.17
Volatile matter	0.40	—
	100.29	99.99

* 19.8°C.

The appreciable difference in manganese would tend to suggest the choice of material of deeper color by the first analyst, but the difference in specific gravity seems too great to be explained by the variation in iron and manganese content.

The pale greenish-yellow garnet, quite plentiful in the locality, was chosen by the author for analysis. The qualitative determinations, together with an indication as to the composition of the dark core material, was kindly furnished by Professor J. Papish in the form of a spectrogram (Fig. 2), which indicates the presence of the following elements: silicon, aluminum, iron, calcium, magnesium, and manganese with a probable trace of titanium. Chromium, barium, strontium, alkalies and the heavy metals were absent. The dark material showed a somewhat greater intensity of iron.

[2] *Compt. rend.*, **73**, 1041, 1871.

[3] *Am. Jour. Sci.*, III, 41, 321–323, 1891.

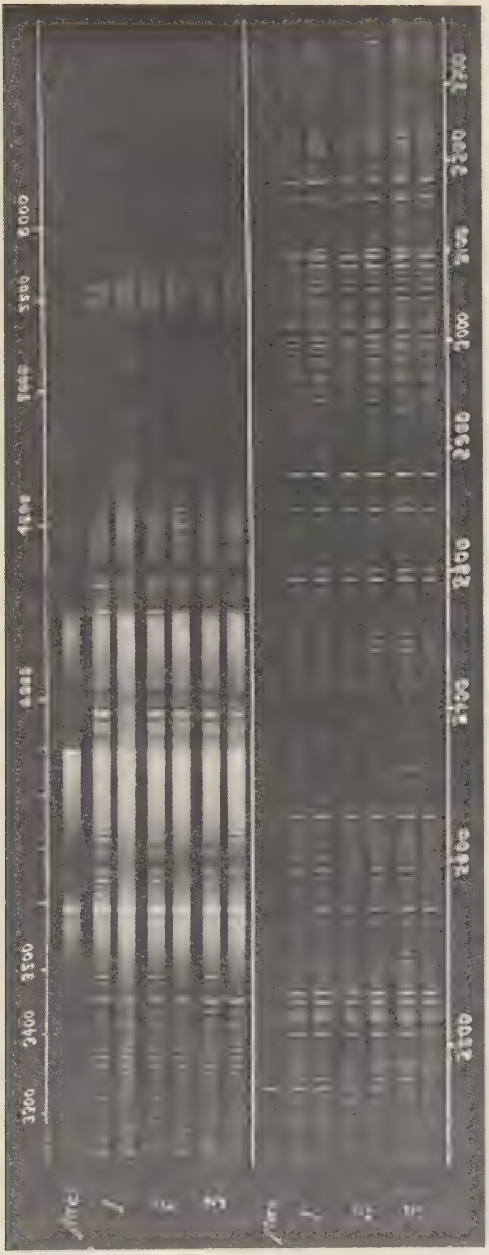


Fig. 2.

1—Pale greenish-yellow garnet, sample I 2—Pale greenish-yellow garnet, sample II 3—Dark brown or black core material.

A sample was prepared for analysis by grinding and separation by means of heavy liquids, after which the material was hand picked with the aid of a lens to exclude contamination by adhering wollastonite or calcite, or material which showed iron stains after washing. Duplicate determinations were made in accordance with the recommendations of W. F. Hillebrand[4] and the results are given in the following tables:

Analysis I (Sample 1.0404 gr.)[5]

		Percent		Ratio of Oxides
SiO_2	.4139	39.78	66.18	3.00
Al_2O_3	.2034	19.56	19.19	1.00
Fe_2O_3	.0468	4.50	2.81	
FeO	.0025	0.24	0.33	2.96
MnO_2	.0017	0.16	0.17	
CaO	.3750	36.06	64.27	
MgO	.0026	0.25	0.62	
TiO_2	probable trace	probable trace		
Volatile matter	.0041	0.41		
	1.0500	100.96		

Analysis II (Sample 1.0029 gr.)

		Percent		Ratio of oxides
SiO_2	.3955	39.43	65.60	3.00
Al_2O_3	.1964	19.58	19.21	1.01
Fe_2O_3	.0457	4.54	2.84	
FeO	.0024	0.24	0.33	2.95
MnO_2	.0015	0.15	0.16	
CaO	.3564	35.53	63.33	
MgO	.0028	0.28	0.69	
TiO_2	probable trace	probable trace		
Volatile matter	.0040	0.40		
	1.0047	100.15		

The relative amounts of the various garnet molecules calculated after the manner of W. E. Ford[6] are:

---

[4] *U. S. G. S. Bull.* **700,** The Analysis of Silicate and Carbonate Rocks.

[5] The higher percentages of calcium oxide and silica in Anal. I as compared with Anal. II may be due to slightly greater contamination of the sample by wollastonite and calcite.

[6] *Am. Jour. Sci.,* **40,** 33–49, 1915.

	Greenish-yellow garnet Analysis II	Rosolite Anal. by de Landero
Grossularite	84.97%	95.68%
Andradite	13.20	1.50
Pyrope	1.07	2.82
Almandite	0.51	—
Spessartite	0.25	—

Both of these analyses show a high percentage of the grossularite molecule.

Specific Gravity

Determinations made with the pycnometer of the specific gravity of the pale greenish-yellow garnet (Analysis II) were: $d_4^{28.3}3.5665$ and $d_4^{25.7}3.5670$.

A determination of the specific gravity of pink material approximating that of de Landero and from the same locality gave at 20.5°C, 3.512 ($d_4^{20.5}3.505$).

The specific gravity of de Landero's material was 3.516 at 19.8°C.($d_4^{19.8}3.510$).

Computations of densities gave the following comparisons:

	Greenish-yellow garnet Analysis II	Rosolite de Landero's Analysis
Calculated density	3.564	3.533
Measured density	3.567	3.510

Refractive Index

Determination on greenish-yellow material (Analysis II) gave $N_{Na}=1.752$. The pink material ($d_4^{20.5}3.505$) was found to have $N_{Na}=1.741$. A colorless variety, though not plentiful enough for density determinations, showed a refractive index very closely approximating that of rosolite, N_{Na} 1.741. The dark brown or black material usually forming the core of the pale greenish-yellow material has an index above 1.780, the highest liquid available.

Computations of refractive indices and Gladstone's constant gave the following results:

	Greenish-yellow garnet Analysis II	Rosolite ($d_4^{20.5}3.505$)
Calc. Refractive index	1.756	—
Meas. Refractive index	1.752	1.741
Gladstone's constant	2108	2111

NOTES AND NEWS

BARIUM-MUSCOVITE FROM FRANKLIN, N. J.

L. H. Bauer and Harry Berman

In June 1932, Mr. J. F. Morton, Director of the Paterson Museum, brought to the Harvard Mineralogical Laboratory for determination a specimen of Franklin ore which he had obtained shortly before on the picking table at the mill. The specimen consisted chiefly of a massive pink mineral with obscure cleavage intermixed with microcline feldspar, yellow garnet, manganophyllite and franklinite. The pink mineral appeared under the microscope to have a micaceous texture and had about the optical characters of muscovite. But its macroscopic appearance was so unlike that of a mica that a chemical analysis seemed necessary to establish its nature.

A sample was purified by Berman and analyzed by Bauer with the result shown below. Alongside of this analysis is that of a barium-muscovite from the Tyrol and the practical identity of the two analyses, taken with the optical characters, establishes the nature of the material. The varietal name oellacherite is given by Dana to this barium-muscovite.

I. Barium-muscovite, Franklin, N. J. Analyst, L. H. Bauer.

II. Barium-muscovite, "oellacherite," *Doelter, Handb. Mineralchemie,* vol. **2,** pt. 2, p. 442. In *Dana, System,* p. 619, no. 62 is a very similar analysis.

	I	II
H_2O	4.05	4.26
SiO_2	41.37	43.07
Al_2O_3	32.64	32.69
MnO	.62	.31
CaO	.36	.23
MgO	1.55	2.90
ZnO	1.84	—
BaO	9.89	5.91
K_2O	6.33	7.61
Na_2O	1.51	1.42
Fe_2O_3	—	1.85
	100.16	100.35

NON-EXISTENCE OF ECHELLITE

N. L. Bowen, *Geophysical Laboratory.*

In 1920 I described as a new mineral, to which the name echellite was given, a crystalline substance coming from Sextant Portage on the Abitibi River, Ontario. (This Journal, **5**, 1–2, 1920.) Professor T. L. Walker now describes (*University of Toronto Studies*, Geol. Series No. **32**, 1932, p. 5) a mineral from the same locality, occurring in the same manner and having the same physical (including optical) properties. His analyses show this mineral to be thomsonite.

If present-day knowledge of the range of optical properties of thomsonite had been available at the time echellite was described, I should have noted that it had properties corresponding with those of a thomsonite and have doubted the accuracy of the analysis. At that time, however, I was unable to find in tables of optical properties of minerals any mineral of similar composition with as high refractive indices. Larsen's tables, for example, give thomsonite in only one place and with $\gamma=1.525$. I even submitted the observed optical properties to friends having readier access to large libraries than I had, asking them to check the values against those of known minerals, but they found nothing to correspond. Since that time I have noted more than one description of thomsonite with indices as high as those of "echellite" and have hoped for the opportunity of re-investigating "echellite." Re-investigation necessitated the acquiring of new material, since the original was exhausted, and the opportunity was never presented. Professor Walker's study now renders it unquestionable that the analysis of "echellite," made on a very small quantity of material, was faulty, and that echellite should be stricken from the list of established species.

PROCEEDINGS OF SOCIETIES

THE PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences, October 6, 1932.

Dr. Cajori presided at a stated meeting of the Philadelphia Mineralogical Society at which 29 members and 30 visitors were present. Mr. E. R. Gudehus was elected a senior member, Mr. W. L. Grierson was proposed for junior membership.

The election of officers resulted as follows:—President, H. W. Trudell; Vice Presidents, J. M. Poley and H. W. Arndt; Treasurer, M. G. Biernbaum; Secretary, W. H. Flack; and Councillor, John Vanartsdalen.

Mr. Toothaker addressed the society on "Czechoslovak Minerals." He described in detail his trip of the past summer to Europe. He visited the silver mines at Pribram, the former silver mines at Joachimsthal which now produce only pitchblende, and the Carlsbad hot springs. He described the method of mining Bohemian garnets. Photographs were shown of basaltic columns measuring 6 inches in diameter and 40 feet in length.

Mr. S. G. Gordon described a trip to Ontario, Canada, visiting the French River district, Sudbury, Cobalt, Timmins, and the Lake Shore Mines.

W. H. Flack, *Secretary*

NEW MINERAL NAMES

Bultfonteinite

John Parry, Alpheus F. Williams, and F. E. Wright: On bultfonteinite, a new fluorine-bearing hydrous calcium silicate from South Africa. *Mineral. Mag.*, **23**, 145–162, 1932.

Name: Presumably from the Bultfontein mine at Kimberley.

Chemical Properties: A fluorine bearing hydrous silicate: $2\ Ca(OH,F)_2 \cdot SiO_2$. Analysis: SiO_2 26.50, $(Al,Fe)_2O_3$ 0.72, CaO 54.20, H_2O 13.36, F. 8.81. Sum 103.59, less $0=3.71$, 99.88. Easily soluble in HCl, yielding a clear jelly. Water extracts calcium hydroxide and yields an alkaline solution. Heated in closed tube, yields water and becomes white and porcelain-like. Before the blowpipe, glows intensely and becomes white and enamel-like, but does not fuse.

Crystallographical Properties: Triclinic. Habit acicular. Completely twinned. $a=0.6756$, $c=0.6873$. $\alpha=94° \ 17'$, $\beta=91° \ 59'$, $\gamma=90° \ 44'°$ $p_0=1.0145$, $q_0=0.6869$, $\lambda=85° \ 41'$, $\mu=87° \ 57'$ $\nu=89° \ 07'$. Cleavages (010), (100), fairly good. Twinning planes (010), (100).

Physical and Optical Properties: Colorless to pink. G.$=2.73$. Hd.$=4\frac{1}{2}$. Fusibility difficult. Biaxial positive. $2V=70°$, $2E=132°$. $\alpha=1.587$, $\beta=1.590$, $\gamma=1.597$. Dispersion weak. Under the microscope shows fine polysynthetic twinning lamellae with high extinction angles. Extinction on (010) is $c:\gamma'=27°$ to 29°, on (100) $c:\gamma'=46°$ to 48°.

Occurrence: First found at the Bultfontein mine, Kimberley, associated with calcite, apophyllite and natrolite, in a large 'horse' of dolerite and shale fragments in kimberlite. Later found in Dutoitspan mine, and still later in Jagersfontein mine. Occurs as radiated spherulitic masses or as radiated acicular needles.

Discussion: Closely related to custerite and hillebrandite as shown by the following comparison.

Hillebrandite	$CaO \cdot Ca(OH)_2 \cdot SiO_2$
Custerite	$CaO \cdot Ca(OH,F)_2 \cdot SiO_2$.
Bultfonteinite	$2Ca(OH,F)_2 \cdot SiO_2$.

W. F. Foshag